

but inward to some extent also, thereby transferring to the so-called Krakatoa wind the energy of the inflowing air streams from higher latitudes. To apply the imagery of Shaw in this connection also, the tropical anticyclones in the high altitudes act as so many gear pumps for the

operation of the high-altitude east-to-west current along the Equator. The competence of these gigantic pumps to perform the several functions assigned to them is indicated by van Bemmelen's table of displacements already referred to.

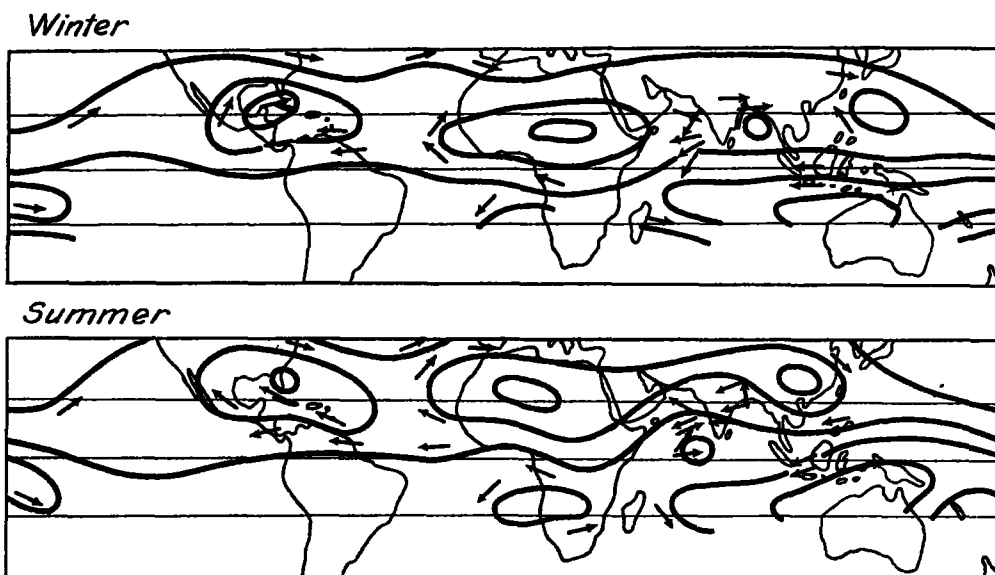


FIG. 3.—Lines of flow of cirrus drift. Reproduced from *MO. WEATHER REV.*, February, 1922, p. 91. See Table 2 of the present paper for data

MITCHELL ON WEST INDIAN HURRICANES AND OTHER TROPICAL CYCLONES OF THE NORTH ATLANTIC OCEAN—A REVIEW

551.515 (261.1) (213)

By ALFRED J. HENRY

The publication under review is the third of the series of memoirs by Weather Bureau officials devoted exclusively to a study of tropical cyclones which at times invade the southeastern United States. It may be helpful at this time briefly to review the two earlier publications¹ and to refer to a Signal Service publication² containing the first official comment upon West Indian hurricanes put forth by the Federal weather service.

This publication, although based upon but 10 year's observations, brings out with remarkable clearness most of the essential facts with respect to the distribution and origin of West Indian hurricanes. The following statement with respect to their origin is significant: "An almost entire absence of reports from the region east of the Windward Islands prevents the tracing of storms to their place of origin."

Garriott's treatment of the subject in Bulletin H is descriptive and historical rather than theoretical, although he gives some space to the theorizing of others. His viewpoint is essentially that of the forecaster and he therefore treats the premonitory signs of the approach of a cyclone rather fully. The historical aspect is also fully considered even to reproducing Poey's list of hurricanes in the West Indies from 1493 to 1855. At least 60 per cent of the space in the bulletin is devoted to a description of individual storms, first by months and again without much regard to the chronological arrangement of the storms, and finally 27 quarto pages are devoted to local records and descriptions of hurricanes drawn from the archives preserved in the islands of both the Greater and the Lesser Antilles. The

example he set is a difficult one to follow in these days of economy and high cost of printing; indeed, the utility of much of the word pictures of experiences in tropical cyclones may well be questioned.

The next memoir, that by Dr. O. L. Fassig, was issued in 1913. It discusses the occurrence of tropical cyclones from a statistical viewpoint, omitting lengthy descriptions of severe storms except in the single case of the August, 1899, storm, which passed directly across Porto Rico and was carefully observed at a number of points in the several quadrants of the cyclone. Both Garriott and Fassig depended for their paths of tropical storms upon the Forecast Division series of daily weather maps as constructed from reports received by telegraph and cable.

Mitchell's studies differ from those of his predecessors in that he replotted the paths of all tropical cyclones of which he could find evidence within the period 1886–1923, using in addition to the Forecast Division charts another series of charts, viz, those taken over from the Hydrographic Office of the Navy and later continued in the Marine Section of the Weather Bureau from mail reports of ships' observations in the North Atlantic and adjacent waters. He was thus able to plot a greater number of storms than did his predecessors, but the outstanding feature of his work was the extension of the paths of storms picked up in or near the Windward Islands far to the eastward, and thus he completely confirmed the opinions expressed by several writers thirty-odd years ago to the effect that the origin of August and September storms would be found in the vicinity of the Cape Verde Islands. Viñes especially gave the reasons why cyclones should develop in the vicinity of the Cape Verde Islands 'in August and not in other months.

¹ Mitchell, Charles L., "West Indian hurricanes and other tropical cyclones of the North Atlantic Ocean," *MO. WEATHER REV. SUPPLEMENT NO. 24*, Washington, 1924.

² Garriott, E. B., "West Indian hurricanes," *W. B. Bull. H.*, Washington, 1900.

and Fassig, O. L., "Hurricanes of the West Indies," *W. B. Bull. X*, Washington, 1913.

³ Dunwoody, H. H. C., Summary of International Meteorological Observations, Washington, 1898.

⁴ Viñes, Benito, S. J., "Investigations of the cyclonic circulation and transitory movement of West Indian hurricanes," *W. B. No. 163*, Washington, 1898, pp. 24–25.

Seventy-odd years ago W. C. Redfield, of New York, collected ships' observations made in connection with an intense tropical storm in the North Atlantic—that of August 30, 1853, and he was able to plot its track from near the Cape Verde Islands west-northwestward to the vicinity of Cape Hatteras where it recurved to the northeast and passing over Rockall Bank was lost in the neighborhood of the Faroes because of lack of ships' reports from that region.

This hurricane, called by Redfield the Cape Verde-Hatteras hurricane, was very definitely plotted for a distance of 7,200 miles; the lowest recorded barometer was 27.30 inches on September 3 in N. latitude 20°; W. longitude 56°, and on September 9 the diameter of the storm extended from Newfoundland to the Azores.⁵

Twenty years later the British Meteorological Office investigated the meteorological conditions that prevailed over the North Atlantic during August, 1873, and issued a very complete monograph as a result.⁶ Doubtless the great majority of meteorologists are familiar with that report, but it would seem as if but few are aware of the earlier record of a similar hurricane by Redfield. Apparently no one sought to trace the paths of West Indian hurricanes back to their origin until Mitchell took up the task in late 1922. His chart of August tracks shows no less than 11 hurricanes having their origin in the immediate vicinity of the Cape Verde Islands. In the first half of September this number falls off almost one-half and in the second half of that month but a single storm is shown as developing in the region just mentioned.

The conclusion is also reached that there is a second place of origin of tropical storms of the North Atlantic, viz, the western third of the Caribbean Sea. Mitchell excludes the eastern two-thirds of that body of water as a place of origin of tropical storms. Early students, Vines, particularly, were of opinion that the entire Caribbean is a region in which tropical storms develop. The ground for the later view is evidently the ships' observations which were not available to early investigators.

A second important conclusion is the definite statement that a tropical storm will recurve to the northward and northeastward at the first favorable opportunity, regardless of the season or the longitude of its position.

That is to say, the pressure distribution of the North Atlantic, especially the Azores anticyclone, determines when and where the recurve will occur.

MONTHLY FREQUENCY

The various memoirs on hurricanes herein quoted make it possible to compare the monthly frequency of these storms as independently determined by the several authors. I have assembled the monthly frequencies in percentages of the whole number of storms and present the numbers in the table following:

¹ W. C. Redfield, "Cape Verde and Hatteras hurricane," Silliman's Journal, second series XVIII, 1-15.

² Meteorology of the North Atlantic during August, 1873, illustrating the hurricane of that month. London, 1878.

TABLE 1.—Frequency of West Indian hurricanes (in per cent) by various authors

Author	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Poëy ¹	1	2	3	2	1	2	12	17	28	19	5	2
Dunwoody ²					0	2	5	28	25	30	3	2
Garriott ³					1	3	3	28	28	34	3	2
Fassig ⁴					1	4	25	32	32	30	1	1
Mitchell ⁵					0	7	7	16	33	30	6	1

¹ 363 years, 1493-1855.

² 10 years, 1878-1887.

³ 23 years, 1878-1900.

⁴ 35 years, 1876-1910.

⁵ 37 years, 1887-1923.

One must be struck with the rather remarkable uniformity in the frequencies for August, September, and October, with but two exceptions, viz, those of October by Poëy and August by Mitchell. Poëy's table may contain at least 10 per cent of extra-tropical cyclones since 5 per cent are reported as having occurred in the winter months alone.

CLASSIFICATION OF CYCLONES

Mitchell in common with other writers has taken into account all storms regardless of their intensity and his statistics should be interpreted accordingly. Fortunately he has given the number recorded in each of the three groups into which they were divided. These groups and the number in each are as follows:

Group No. 1. Storms of known hurricane intensity (winds of at least 60 m. p. h.)	122, or 51 per cent.
Group No. 2. Storms whose intensity is in doubt, because of an insufficient number of reports	57, or 24 per cent.
Group No. 3. Storms known to have been of less than hurricane intensity	60, or 25 per cent.

The monthly distribution of all storms considered by Mitchell is found to be as follows, total number of storms plotted in each month:

May	1
June	16
July	17
August	39
September	78
October	71
November	15
December	2
Total	239

The SUPPLEMENT is illustrated by 9 charts of paths followed by the tropical storms of the North Atlantic and many weather charts (mostly isobars only) portraying the pressure distribution in typical severe storms in the several months of the hurricane season. The publication is not for general free distribution; copies may be had from the Superintendent of Documents, Washington, D. C. to whom remittances should be made. The price of the publication is 50 cents.